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Assessing the Geothermal Parameters by Integrating Geophysical and Geospatial Techniques at Siwa Oasis, Western Desert, Egypt

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Abstract : Many regions in Egypt are facing a reduction in crop productivity due to environmental degradation. One factor of crop deterioration includes the unsustainable drainage of surface water, leading to salinized soil conditions. Egypt has exerted time and effort to identify solutions to mitigate the surface water drawdown problem and its resulting effects by exploring renewable and sustainable sources of energy. Siwa Oasis represents one of the most favorable regions in Egypt for geothermal exploitation since it hosts an evident cluster of superficial thermal springs. Some of these hot springs are characterized by high surface temperatures and bottom hole temperatures (BHT) ranging between 20°C to 40 °C and 21 °C to 121.7°C, respectively. The depth to the Precambrian basement rock is commonly greater than 440 m, ranging from 440 m to 4724.4 m. It is this feature that makes the locality of Siwa Oasis sufficient for industrial processes and geothermal power production. In this study, BHT data from 27 deep oil wells were processed by applying the widely used Horner and Gulf of Mexico correction methods to obtain formation temperatures. BHT, commonly used in geothermal studies, remains the most abundant and readily available data source for subsurface temperature information. Outcomes of the present work indicated a geothermal gradient ranging from 18 to 42 °C/km, a heat flow ranging from 24.7 to 111.3 m.W.k^{-1}, and a thermal conductivity of 1.3–2.65 W.m^{-1}.k^{-1}. Remote sensing thermal infrared, topographic, geologic, and geothermal data were utilized to provide geothermal potential maps for the Siwa Oasis. Important physiographic variables (including surface elevation, lineament density, drainage density), geological and geophysical parameters (including land surface temperature, depth to basement, bottom hole temperature, magnetic, geothermal gradient, heat flow, thermal conductivity, and main rock units) were incorporated into GIS to produce a geothermal potential map (GTP) for the Siwa Oasis region. The model revealed that both the northeastern and southeastern sections of the study region are of high geothermal potential. The present work showed that combining bottom-hole temperature measurements and remote sensing data with the selected geospatial methodologies is a useful tool for geothermal prospecting in geologically and tectonically comparable settings in Egypt and East Africa. This work has implications for identifying sustainable resources needed to support food production and renewable energy resources.

Keywords : BHT, geothermal potential map, geothermal gradient, heat flow, thermal conductivity, satellite imagery, GIS
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